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Notes:

1. Untranslatable words are replaced with asterisks (* **).
2. Texts in the figures are not translated and shown as it is.

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CLAIM + DETAILED DESCRIPTION

[Claim(s)]

[Claim 1] Following general formula (** 1) [Chemical formula 1]



1, 6-anhydrosugar, following general formula (** 2) [Chemical formula 2] which are come out of and expressed



1, 4-anhydrosugar, following general formula (** 3) [Chemical formula 3] which are come out of and expressed



1, 3-anhydrosugar, following general formula (** 4) [Chemical formula 4] which are come out of and expressed



1 and 2-anhydrosugar and following general formula (** 5) [Chemical formula 5] which are come out of and expressed



Multi-branching polysaccharide which is the polymer of at least one sort of anhydrosugar which comes out and is chosen from 5 expressed and the group which consists of 6-anhydrosugar (R may be the same respectively, or you may differ, and a hydrogen atom or a carbon number expresses the hydrocarbon group of 1-30 among a formula.).

[Claim 2] Multi-branching polysaccharide according to claim 1 said whose hydrocarbon group is an alkyl group, an aryl group, or an alkyl aryl machine.

[Claim 3] Multi-branching polysaccharide according to claim 1 or 2 whose degrees of branching are 0.05-1.00.

[Claim 4] Following general formula (** 1) [Chemical formula 1]



1, 6-anhydrosugar, following general formula (** 2) [Chemical formula 2] which are come out of and expressed



1, 4-anhydrosugar, following general formula (** 3) [Chemical formula 3] which are come out of and expressed



1, 3-anhydrosugar, following general formula (** 4) [Chemical formula 4] which are come out of and expressed



1 and 2-anhydrosugar and following general formula (** 5) [Chemical formula 5] which are come out of and expressed



5 come out of and expressed, 6-anhydrosugar ([R / R may be the same respectively, or may differ, and] among a formula) a hydrogen atom or a carbon number expresses the hydrocarbon group of 1-30. from -- process of the multi-branching polysaccharide which consists at least one sort of anhydrosugar chosen from the group which changes of polymerizing under existence of a cation initiator or an anion initiator.

[Claim 5] The process according to claim 1 said whose hydrocarbon group is an alkyl group, an aryl group, or an alkyl aryl machine.

[Claim 6] The process according to claim 1 or 2 whose degrees of branching of said multi-branching polysaccharide are 0.05-1.00.

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to multi-branching polysaccharide useful as the thickener as a high draw gel of biocompatibility, a medical base material of biocompatibility, etc.

[0002]

[Description of the Prior Art] Since the polysaccharide synthesis by a chemical procedure aims at synthesis of the normal chain-like polysaccharide which exists naturally, or its analog, generally synthetic polysaccharide is a normal chain-like. For example Schuerch, etc. Uryu, etc. [with the cation ring opening polymerization of anhydrosugar] [various normal chain-like polysaccharide (the polymer 40 volume February issue (1991); Adv.Carbohydr.Chem.Biochem., vol.39, Academic Press (1981) p.157)] Nakatsubo etc. does cation ring opening polymerization of the ortho ester object of a monosaccharide, and is compounding cellulose and its derivative (J.Am.Chem.Soc.1996, 118, 1677-1681;Macromolecules.1996, 29, 6126-6131). However, by a method which was described above, generation polysaccharide is limited in the shape of a normal chain. As an example of chemosynthesis for obtaining multi-branching polysaccharide, only synthesis of multi-branching amino polysaccharide by the glycosylation reaction of a sugar oxazoline derivative is reported by Kadogawa etc. (chemistry and industry volume [54th] No. 2 168-171 (2001)). However, the conformity range of this method is restricted only to aminosugar, and the application to other saccharides is difficult for it.

[0003]

[Means for solving problem] It was completed and this invention offers the method of manufacturing multi-branching polysaccharide and it which are obtained by polymerizing under existence of a cation initiator or an anion initiator in anhydrosugar, as a result of repeating research wholeheartedly, in order to carry out chemosynthesis of the multi-branching polysaccharide simple. This invention Namely, following general formula (** 1) [Chemical formula 1]



1 come out of and expressed, and 6-anhydrosugar (for example, 1 and a 6-anhydro beta-D-glucopyranose derivative --> 1, a 6-anhydro beta-D-MANNO pyranose derivative, 1, a 6-anhydro beta-D-galactopyranose derivative, A 1, 6-anhydro beta-D-AROPIRANOSU derivative, 1, and 6-anhydro beta-D-altro pyranose derivative etc. is mentioned. Following general formula (** 2) [Chemical formula 2]



1 come out of and expressed, and 4-anhydrosugar (for example, 1 and a 4-anhydro beta-D-ribofuranose derivative --> A 1, 4-anhydro alpha-D-xylopyranose derivative, 1, 4-anhydro alpha-L-arabino pyranose derivative, 1, and 4-anhydro alpha-D-lyxo pyranose derivative etc. is mentioned. Following general formula (** 3) [Chemical formula 3]



1, 3-anhydrosugar (for example, a 1, 3-anhydro beta-D-glucopyranose derivative, 1, and 3-anhydro beta-D-MANNO pyranose derivative etc. is mentioned.), following general formula (** 4) [Chemical formula 4] which are come out of and expressed



1 and 2-anhydrosugar (for example, a 1, 2-anhydro alpha-D-glucopyranose derivative, 1, and 2-anhydro beta-D-MANNO pyranose derivative etc. is mentioned.) and following general formula (** 5) [Chemical formula 5] which are come out of and expressed



It is multi-branching polysaccharide which is the polymer of at least one sort of anhydrosugar which comes out and is chosen from 5 expressed and the group which consists of 6-anhydrosugar (for example, a 5 and 6-anhydro alpha-D-glucopyranose derivative etc. is mentioned.).

[0004] Among each above-mentioned formula, R may be the same respectively or may differ, the hydrocarbon group of 1-4 is expressed preferably, and 1-30, and that they are an alkyl group, an aryl group, or an alkyl aryl machine have [this hydrocarbon group] a hydrogen atom or a carbon number desirable [R]. Moreover, this invention is the process of the multi-branching polysaccharide which consists at least one sort of anhydrosugar chosen from the above-ization 1-5 of polymerizing under existence of a cation initiator or an anion initiator.

[0005] moreover, the degree of branching of this multi-branching polysaccharide -- desirable -- 0.05-1.00 -- it is 0.6-1.0 more preferably. As for the degree of many branching, expressing with one of the following is general.

(1) The formula of Frechet : degree of branching =(number of number of branching units + polymer ends)/(the number of number of number of branching units + polymer ends + normal chain units)

(2) The formula of Frey : degree of branching =(number of number of branching units + polymer ends-molecularity)/(number of number of number of branching units + polymer ends + normal chain units-molecularity)

When the molecular weight of a polymer is low, in order that the influence of a central nucleus may come out strongly, the formula of Frey is more exact, but when a degree of polymerization is high enough, both show the same value. In this invention, the formula of Frechet is usually applied. As for the degree of branching of normal chain-like polymer, 0 and the degree of branching of a dendrimer are set to 1. However, since the degree of branching of the polysaccharide obtained by this invention is a new substance, it is difficult to estimate correctly at present, and the degree of branching changes also with manufacture conditions.

[0006]

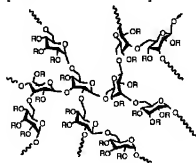
[Mode for carrying out the invention] The process of multi-branching polysaccharide of this invention is described hereafter. The anhydrosugar used for a raw material by this invention can be obtained the decomposition by the microwave of wood, or by carrying out a pyrolysis. As anhydrosugar used in this invention, 1, 6-anhydro beta-D-glucopyranose, 1, such as 1, 6-anhydro beta-D-MANNO pyranose, 1, and 6-anhydro beta-D-galactopyranose, 6-anhydrosugar, 1, such as 1, 4-anhydro beta-D-ribopyranose, 1, and 4-anhydro alpha-D-

glucopyranose, 4-anhydrosugar, and these derivatives can be raised. Furthermore, 1, 3-anhydrosugar, 1, 2-anhydrosugar, 5, 6-anhydrosugar, 3, and 5-anhydrosugar and those derivatives can also be used.

[0007] Although a cation initiator or an anion initiator is used as an initiator used for this multi-branching polysaccharide manufacture reaction In the case of 1, 6-anhydrosugar, 1, 4-anhydrosugar, 1, 3-anhydrosugar, 1, 2-anhydrosugar, 3, 5-anhydrosugar, 5, and 6-anhydrosugar, in the case of 1, 2-anhydrosugar, 5, and 6-anhydrosugar, an anion initiator is used using a cation initiator. As a cation initiator, Broensted acid, such as Lewis acid, such as heat cation initiators, such as sulfonium antimonate, an optical cation initiator, boron trifluoride, a tin tetrachloride, antimony pentachloride, and phosphorus pentafluoride, and trifluoro methansulfonic acid, can be used preferably. As an anion initiator, metal alcoholate, such as hydroxides, such as KOH, tert-BuOK, and $Zn(OCH_3)_n$, is desirable. The amount of the initiator used in a multi-branching polysaccharide manufacture reaction is less than 5wt% to a raw material (anhydrosugar), and is less than 1wt% preferably. As an organic solvent, propylene carbonate, ethylene carbonate, The multi-branching polysaccharide manufacture reaction which can use aprotic polar solvents, such as dimethyl imidazolidinone and 1,4-dioxane, is faced, it mixes and dissolves well under warming of anhydrosugar and an organic solvent, and an initiator is added after that. When not using a solvent, anhydrosugar is dissolved with heat and an initiator is added after that.

[0008] Multi-branching polysaccharide of this invention is a bottom type (** 6).

[Chemical formula 6]



It is thought that it comes out and the form expressed is carried out (R is the same as that of the above among this general formula (** 6)). That is, anhydro binding of 1 of sugar which is raw material, 4-, 1, 3-, 1, 2-, 5, 6-, 3, and 5- is considered to constitute the polymer which carried out ring breakage, combined with the hydroxyl group of other sugar, and branched. In addition, the initiator, the metal in a reactional solvent, etc. may have replaced by R in this formula. For example, in ** 4 or the compound of 5, if it polymerizes with initiators, such as KOH, potassium ion will remain as R, and if the polymer from the compound of ** 1-5 is melted in NaOH or a KOH aqueous solution, the proton of a hydroxyl group will change to a metal ion.

[0009] The degree of branching has a form near arborescent highly (close to 1), and such polymer (multi-branching polysaccharide) is considered that branching is further made also of branched chain. On the other hand although branched state polysaccharide is indicated by JP,8-41104,A and JP,8-277303,A Almost all the things of sugar before reacting at least by 1 and 6- are normal chains-like, after treatment is foliaceous branching polysaccharide of a pine, the short side chain (a monosaccharide and oligosaccharide) has combined it with normal chain-like polysaccharide, and it is thought that at least 1 and 6- does not have the further branching in branched chain. Therefore, it is thought that the degree of branching of these polysaccharide is quite lower than the thing of this invention.

[0010]

[Effect of the Invention] According to this invention, water-soluble multi-branching polysaccharide can be compounded with sufficient reproducibility in large quantities, and this is enabled to use multi-branching polysaccharide as a functional material on a scale of industrial. Furthermore, in the supply from natural branching polysaccharide, such as amylopectin, preparation of the impossible molecular weight or the degree of branching of this invention is attained, and it can supply multi-branching polysaccharide according to a use.

[0011]

[Working example] Hereafter, although this invention is illustrated in the work example, it does not mean limiting this invention.

In work-example 1 this example, solution polymerization of 1 and 6-anhydro beta-D-glucopyranose was performed. The bottom of nitrogen-gas-atmosphere mind, and in a SHURENKU pipe, 1, 6-anhydro beta-D-glucopyranose (1.3g, Tokyo Chemicals), Desiccation propylene carbonate (3.2mL, Aldrich, monomer concentration 2.5 mol-dL-3), and -- as a thermal initiator -- 66wt% 2-butylnyl tetramethylene sulfonium hexafluoroantimonate (17.1micrOL --) After having put in Asahi Denka Kogyo, heating at 100 degrees C by the oil bath and dissolving 1 and 6-anhydro beta-D-glucopyranose, it warmed to 130 more degrees C, and the polymerization was started. 30 minutes afterward, the polymerization solution was poured out into methanol and the polymerization was suspended. It refined by reprecipitating with water and methanol after distilling off a solvent. The yield of 0.41g, 31.8% of a yield. Specific rotation [alpha] D+89.9 degrees (c 1.0, H2O, 23 **). Weight average molecular weight 2,400 (SEC, a 0.2 % sodium nitrate aqueous solution, 40 degrees C), dispersion 1.7.

[0012] 1H NMR spectrum and 13C NMR spectrum of a product are shown in drawing 1 and drawing 2, respectively. As opposed to only one peak of the carbon origin of (C1) not appearing in polysaccharide of a normal chain at least in anomer In polysaccharide of this invention, that it is divided in several (near 100 ppm) (also setting to drawing 2, below-mentioned drawing 4, and 6 the same.), and polysaccharide is generating by various bonding patterns, and since the peak of other carbon is similarly divided in several, it turns out that

generation polysaccharide is many branched state. the weight average molecular weight which the weight average molecular weight measured by the SEC method measured with static light scattering measurement -- also depending -- it comes out small. This trend is based on the difference in the sensitive volume of polymer, and many branched polymer is sufficient as it, and it is observed.

[0013] In work-example 2 this example, block polymerization of 1 and 6-anhydro beta-D-glucopyranose was performed. It is 1 and 6-anhydro beta-D-glucopyranose (1.6g) the bottom of nitrogen-gas-atmosphere mind, and in a SHURENKU pipe. After having put in Tokyo Chemicals, heating to 180 degreeC by the oil bath and dissolving 1 and 6-anhydro beta-D-glucopyranose, 66wt% 2-butynyl tetramethylene sulfonium hexafluoroantimonate (17.1microL, Asahi Denka Kogyo) was added as a thermal initiator, and the polymerization was started. 1 minute afterward, the product was dropped into methanol and the polymerization was suspended. It refined by reprecipitating with water and methanol after distilling off a solvent. The yield of 0.74g, 46.3% of a yield. Specific rotation $[\alpha]_D^{+87.0}$ degrees (c 1.0, H₂O, 23 **). Weight average molecular weight 4,300 (SEC, a 0.2wt% sodium nitrate aqueous solution, 40 degrees C), dispersion 1.3. Weight average molecular weight 9,400 (a static light-scattering measuring method, 0.1 mol-dL-3 sodium chloride aqueous solution, 25 degrees C). The solubility (concentration: 30 mg/mL, dissolution time:1 hour) to the various solvents of a product is shown in Table 1.

[0014]

[Table 1]

H ₂ O	MeOH	EtOH	アセトン	CH ₂ Cl ₂	CHCl ₃	DMSO	1,4-DO	PC	EC	DMI
○	×	×	×	×	×	○	×	×	×	○

As for O, the dissolution and x express non-** with a room temperature among front, and each cable address is DMSO. : Dimethyl sulfoxide, 1, 4-DO: 1,4-dioxane, Pc : Propylene carbonate Ec : Ethylene carbonate and DMI: 1,3-dimethyl-2-imidazolidinone is expressed. Sample data were obtained by block polymerization (above) of 1 and 6-anhydro beta-D-glucopyranose. 1H NMR spectrum and 13C NMR spectrum of a product are shown in [drawing 3](#) and [drawing 4](#), respectively.

[0015] In work-example 3 this example, solution polymerization (the 1) of 1 and 6-anhydro beta-D-MANNO pyranose was performed. It is 1 and 6-anhydro beta-D-MANNO pyranose (2.2g) the bottom of nitrogen-gas-atmosphere mind, and in a SHURENKU pipe. Synthesis from D-mannose, desiccation propylene carbonate (4.3 mL) as Aldrich, monomer concentration 3.2 mol-dL-3, and a thermal initiator -- 66wt% 2-butynyl tetramethylene sulfonium hexafluoroantimonate (14.2microL --) After having put in Asahi Denka Kogyo, heating at 100 degrees C by the oil bath and dissolving 1 and 6-anhydro beta-D-MANNO pyranose, it warmed

to 130 more degrees C, and the polymerization was started. 20 minutes afterward, the polymerization solution was poured out into methanol and the polymerization was suspended. It refined by reprecipitating with water and methanol after distilling off a solvent. The yield of 1.22g, 56.6% of a yield. Specific rotation $[\alpha]_D^{+50.2}$ degrees (c 1.0, H₂O, 23 °C). Weight average molecular weight 2,800 (SEC, a 0.2% sodium nitrate aqueous solution, 40 degrees C), dispersion 1.8. The solubility to the various solvents of a product is shown in Table 2. [0016]

[Table 2]

H ₂ O	MeOH	EtOH	アセトン	CH ₂ Cl ₂	CHCl ₃	DMSO	1,4-DO	PC	EC	DMI
○	×	×	×	×	×	○	×	×	×	△

However, concentration : 30 mg/mL, dissolution time : 1 hour. ○ The dissolution and × of the dissolution and ** are insoluble at 90 degrees C at a room temperature. DMSO: Dimethyl sulfoxide, 1, 4-DO: 1,4-dioxane, Pc : Propylene carbonate Ec : Ethylene carbonate and DMI: 1,3-dimethyl-2-imidazolidinone. Sample data were obtained by solution polymerization (above) of 1 and 6-anhydro beta-D-MANNO pyranose. ¹H NMR spectrum and ¹³C NMR spectrum of a product are shown in drawing 5 and drawing 6 , respectively.

[0017] In work-example 4 this example, solution polymerization (the 2) of 1 and 6-anhydro beta-D-MANNO pyranose was performed. It is 1 and 6-anhydro beta-D-MANNO pyranose (1.7g) the bottom of nitrogen-gas-atmosphere mind, and in a SHURENKU pipe. D-mannose to synthesis, and desiccation propylene carbonate (3.5 mL) After having put in Aldrich and monomer concentration 3.0 mol-dL-3, heating to 90 degreeC by the oil bath and dissolving 1 and 6-anhydro beta-D-MANNO pyranose, 66wt% 3-methyl 2-butynyl tetramethylene sulfonium hexafluoroantimonate (11.4microL, Asahi Denka Kogyo) was added as a thermal initiator, and the polymerization was started. 20 minutes afterward, the polymerization solution was poured out into methanol and the polymerization was suspended. It refined by reprecipitating with water and acetone after distilling off a solvent. The yield of 1.11g, 63.8% of a yield. Specific rotation $[\alpha]_D^{+6.9}$ degrees (c 1.0, H₂O, 23 °C).

[0018] In work-example 5 this example, solution polymerization of the 1 and 6-anhydro beta-D-galactopyranose was performed. It is the 1 and 6-anhydro beta-D-galactopyranose (0.8g) the bottom of nitrogen-gas-atmosphere mind, and in a SHURENKU pipe. Tokyo Chemicals and desiccation propylene carbonate (5.0mL and Aldrich --) as monomer concentration 1.0 mol-dL-3 and a thermal initiator -- 66wt% 2-butynyl tetramethylene sulfonium hexafluoroantimonate (10.5microL --) After having put in Asahi Denka Kogyo, heating to 100 degreeC by the oil bath and dissolving the 1 and 6-anhydro beta-D-galactopyranose, it warmed to 130 more degreeC and the polymerization was started. 40 minutes afterward, the polymerization solution was poured out into methanol and the polymerization was suspended. It refined by reprecipitating

with water and methanol after distilling off a solvent. Yield of 0.29g 36.8% of yield. Specific rotation $[\alpha]_D^{+87.8}$ degrees (c 1.0, H₂O, 23 **).

[Translation done.]